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Discussion on Mr. Armitage's Paper Entitled "The Application of Manufacturing Methods to Non-Repetition Work."

(November 26th, 1926.)

MR. HUTCHINSON, President of the Institution, in opening the discussion, said that they had listened to an excellent exposition of a very difficult subject. There were two aspects of Mr. Armitage's paper which struck him. One that it was rather a difficult paper to discuss, because, as far as it was possible, he had dealt with the subject very completely; and moreover, that it was just as well that it was not broadcast from 2LO, because he felt sure they would all have got into trouble for oscillating. He meant that he found it very difficult to determine just when Mr. Armitage was dealing with repetition work and when he was dealing with non-repetition work. It struck him that he oscillated rather from one phase of the subject to the other, because many of the points which he raised with regard to non-repetition work he failed to follow up, whilst the methods of

handling parts in the shop that he described, very quickly drifted into the methods which could only be used in connection with quantity repetition work. As an example, he talked about conveyors. At the time Mr. Armitage was dealing with parts in batches of 15, 20 and 25, and then he had switched off on to conveyors. He would like to know what Mr. Armitage had in mind as to the use of conveyors in a purely general engineering works, especially as he went on to say that a conveyor had a psychological effect on the operator because he saw his work in front of him. It was difficult, however, to imagine half a dozen lathe beds sliding down in front of an operator on a conveyor.

Mr. Armitage had referred to one point which was of very great importance, but which, unfortunately, many of us did not meet with, *i.e.*, the question of design being subservient to manufacturing facilities. If we could only get designers to realise that the manufacturers and producers in any works were the most likely people to know how a part could be designed for the cheapest possible means of manufacture, then we, as a body of engineers, would have done a very great deal for the industry in which we were particularly interested. His own experience was that the designer went ahead with his work in many cases without any idea as to how it was to be produced, and if it was suggested that the design should be altered to make it easier to manufacture, the designer was inclined to take up the attitude that his critics were exceeding their duties. This raised the old question, of course, that the designer, as in the old days, should serve his full time in the shops. Unfortunately, that point was frequently overlooked nowadays, but he thought the time was coming when the management of firms were beginning to appreciate that the producers in the factory were of importance, and it was up to us to propagate that doctrine as far as we could.

A point in Mr. Armitage's paper which impressed him as particularly commendable, and in which he entirely agreed, was that wherever we felt the pinch of American or foreign competition in this country, our manufacturers were invariably able to recover the field. Mr. Armitage had mentioned bicycles, typewriters and sewing machines, and he might have added the Morris car. That was one of the best examples of all, because it showed that although we had not approached or dreamed of an output comparable with that of the Ford car, we had, in spite of a much smaller output in this country, been able to compete most successfully with the Ford.

Another point was the grouping of machine tools for the manufacture of the components of any particular assembly. That, in his opinion, essentially called for a continuous flow of work. Where one had anything in the nature of jobbing work it was far better to group machine tools in classes, drilling machines, milling

machines, centre lathes, etc. The reason for this was that it was possible, by concentration or specialisation on a particular type of machine, to obtain better supervision over the machine operators, and a higher degree of skill by grouping the machines in types rather than in assemblies. On repetition work, on the other hand, the necessary skill was acquired by constant practice in doing the same work over and over again. Perhaps Mr. Armitage would give us some actual experiences on work which he had put through in small quantities.

MR. H. A. DUDGEON, Member of Council, said that he had come to listen to the discussion rather than to speak, but there was one statement Mr. Armitage had made which he thought would make for a misunderstanding. He had referred to several manufacturers meeting foreign competition in the production of bicycles, sewing machines and motor cars. As far as sewing machines were concerned, there were in this country only three concerns manufacturing sewing machines, one of which was a small firm, and the larger of the other two was controlled by American capital, although British labour was employed.

In referring to piece work in the tool room, Mr. Armitage had said that the earnings of the men were increased, and that the output of the tool room was also increased. He would be interested to know whether the work itself had increased in cost, taking into account the higher wages paid to the men and the extra staff necessary to keep track of what the men were doing and any extra help required for men engaged in the tool room proper.

MR. ARMITAGE, in reply to Messrs. Hutchinson and Dudgeon, said that the President raised the matter of conveyors in a general engineering works, and had also asked for his idea of a general engineering works. (Using a blackboard illustration Mr. Armitage sketched a works plan showing the foundry, forge, bar stores, main machine shops, and assembly department.) Supposing the raw material be received at the point indicated on the plan, this must be transported to the machine shops, whilst transport was also necessary between the machine shops and the erecting shop, and the foundry and the general machining department. There was excellent use for conveyors in this work, and it would not be necessary to have a truck to bring the work into the machine shop or to have trucks in the bar stores.

In referring to modern conveyors, he did not necessarily mean only gravity conveyors. Generally speaking, it would be found that power conveyors would be cheaper besides being more universal and adaptable than gravity conveyors. With a suitable conveyor system, works transport cost next to nothing, and it was possible to buy a large conveyor for about the same price as one paid for a capstan lathe. When once that fact was appreciated,

he thought they would rarely see a works without conveyors to serve the machine tools.

The next question mentioned was that of design. Personally, he was taking perhaps an opposite line to that taken by most production engineers, but he considered that the design side should have the stronger pull in the control of a works product than the production side. Where the producers were in a stronger position than the designers it would invariably be found that the product would fall off greatly in quality, as the first consideration became cheap manufacture. It was not necessary to mention names by way of example, as members would readily call to mind cases where this had happened. He could assure them that at the Austin Company, design was the first consideration, and the production people had to keep up with the refinements that were continually being introduced. However, they generally managed to produce what was required.

Again, Mr. Hutchinson had raised the question of design in general engineering works. There was a prevailing idea that people would not buy a machine unless it was just the thing they wanted, and general engineers in particular had got into the habit of building anything that might be asked for. Customers wanted this, that, and the other, and although they might perhaps know exactly what they wanted, nevertheless he felt certain that if customers were producers they would, generally speaking, get far better value for their money, a far better quality of article, and a far more useful machine, by not sticking out for so many of their own ideas in it. Greater standardisation was possible, especially when dealing with orders for Government or Municipal departments. Very often they found that a Borough Surveyor or Engineer, feeling it incumbent upon him to justify his position by some means or other, would hold out for all manner of unnecessary additions or modifications.

Mr. Hutchinson had raised the question of grouping machines. In the paper it was suggested that machines should certainly be grouped according to class in a general engineering works. There was every reason why this grouping should be adopted, and there was no valid reason against it. The advantages were that each foreman was a specialist on his own particular job; in the capstan lathe section there was a capstan lathe expert, in the drilling department an expert able to handle any drilling machine trouble, a specialist on automatics in the automatic section, and so on. On the other hand, with isolated machines (taking, for example, drilling machines), each machine would require a set of drills, adapters, chucks, angle plates, and other tackle, whereas the same amount of equipment could be divided amongst a dozen machines situated in a group. The same will apply to capstan equipment, so that, instead of a single machine requiring a complete set of

expensive accessories, 20 sets of equipment would probably be sufficient to run 50 capstan lathes grouped together. Equally important is the question of grouping in its effects on the operators. When, for example, a new operator enters a shop where he is amongst 20 or 30 other operators on similar work, he will see the standard of work set up by the other men, and will realise that he must attain that standard very quickly or get out. Therefore, in a general engineering works there was no question that machines ought to be grouped. In a factory engaged on repetition work, on the other hand, the latest practice, as mentioned in the paper, was not to group machines according to type, as this involved an excessive amount of internal works transport. Instead of a group of machines, a line of machines is so organised that the output is balanced and the finished work can be taken from each machine straight away. On repetition work one man could be made responsible for a certain sub-assembly or a certain portion of the machines that were working. If, for example, a man had to make a hundred camshafts in a week, that man would be responsible for making them completely, whereas if they had to go first to the lathes, and then to the hardening shop, the grinding section, and so on, it would be found that in each of those places work was dumped down, and delays arose before the particular operation was carried out on the shafts. The result was that probably something like 2,000 camshafts would be in process of manufacture, whereas with a group assembly the whole section could probably be run with not more than a week's output in operation at any one time. The ambition, of course, of every manufacturer was to turn over his stock as quickly as possible.

With regard to the sewing machines which Mr. Dudgeon had mentioned, he certainly thought that the sewing machines were English machines, and he could not recollect having seen American sewing machines in England.

With regard to the staff required for the rate-fixing in the tool room, they had tried this purely as an experiment, and it was found that one rate-fixer could deal with 50 or 60 tool room operators. At present they had about 200 men in the tool room and four rate-fixers were sufficient to deal with them. In the remainder of the factory approximately 9,000 people were employed, and five rate-fixers were necessary to cover them. Times and prices were, however, planned in advance. The rate-fixer's principal duty was to make price agreement with the operator when it was passed to the works. In the tool room, however, the economy effected by the rate-fixers had far more than paid for itself. Actually they had 40 men less in the tool room than they had formerly, although the tool room was handling 28 per cent.

more work. There was, therefore, no question about the economy effected from that point of view.

MR. A. WILLMOTT, Member, said that he thought they were all very interested in the paper which Mr. Armitage had taken such trouble to give them. As the Chairman had said, the paper was full of very contentious matter, and there was one point that struck him regarding non-repetition work, *i.e.*, the use of conveyor systems. In place of conveyor systems he would like to put forward the lifting truck. Personally, and from experience on light and medium work, he had found the lifting truck to be the means of very great economies in moving work. If properly designed, and the truck worked in conjunction with work platforms, or transport boxes, as the case might be, the trucker did nothing else but pick up the transport boxes and platforms and remove them from one place to the other. These trucks, with one man, were capable of moving tons of work per day, and in an ordinary repetition engineering shop, where the components were not unduly heavy, he thought that presented by far the most economical method of transport.

Another point raised in the paper was that design was so often governed by manufacturing facilities. An alternative view to this was that the designer is a man of special knowledge, and although one might endeavour to get him down into the shop to see what the manufacturing facilities were, it was impossible to get this knowledge ingrained into him. One method of providing for this was to pass the designs from the design office to the works office, where they were reviewed by men particularly skilled in shop methods. These men dissected the design so that it could be handled more efficiently with the plant that was available. The designs then went back again to the designers to see whether anything had been altered which materially affected the efficiency which the designer had originally endeavoured to obtain. The drawings were then finally revised and the working drawings laid out. This scheme had been found to work exceedingly well.

With regard to the question of grouping machines, there was one thing that he found, that was the paucity of room round the machines and for a simple and adequate way of keeping the machine supplied with work. In his opinion, in the average English machine shop there was not enough gangway room, or not enough room for putting down and taking away the work from each machine. What are required are lines marked out on the floor to define the gangways, and some system of moving the work which is going forward to the next section immediately the work is done, so that it is automatically taken away, practically without specific instructions.

MR. GARTSIDE, Member, said that from the title of Mr. Armitage's paper he had expected to hear something that was really

helpful to him in the particular line of business in which he was engaged. He thought, in the first place, Mr. Armitage ought to have made it quite clear as to what he called a general engineering shop, and he was rather inclined to agree with the President that he had oscillated. If all engineering shops were arranged like the plan which Mr. Armitage had drawn on the blackboard, things would be very much easier to deal with than at the present time. Unfortunately, he did not think he would find many general engineering shops laid out in that way. He would require two or three more dimensions in drawing to represent the average general engineering shop, and the question of conveyors would be a very difficult problem. As for gravity conveyors, he was afraid they would come down with rather a shock in some shops.

Besides defining what a general engineering shop really is, Mr. Armitage should also have defined general engineering work. In their business, if they got six off they would call it a repetition job. One of the main things in order to help in introducing repetition methods in general engineering works was the standardisation of parts. As most of the members were aware, he was engaged with building machine tools, and they very seldom made two machines alike. Apart from machine tools they made other machines as well, which meant that they had a large variety of articles to deal with. For machine tools alone he had always argued that (and could not see why it could not be carried out) with a little organisation there need be no two kinds of change wheels in a machine shop. Take the average machine shop to-day, however, and the various types of lathes and milling machines and other machine tools where change wheels were used : unless the machines came from the same maker there were not two sets of change wheels alike. This was one thing that ought to be standardised either in this country or all over the world.

Another item which might be introduced was a standard hand-wheel. One found each different maker supplying a different kind of handle, but none performing the required function any better than the rest. If these and many other parts were standardised they could all be produced on repetition lines, and the advantages of repetition ideas obtained in building even special machine tools.

With regard to the question of production and design, he was a firm believer that the best designer is the man who had spent some period of his time in the shops actually working the machines that he is to design. That was his own experience, and he found that when he first went into the drawing office he could put on the board many improvements of the machines that suggested themselves to him whilst he was working them. He thought it should be part of a designer's training that he should spend a certain period of his time in the works ; he knew they did not like it, but it did them a lot of good.

MR. PATTINSON, Member, said he would like to criticise Mr. Armitage's paper a little. He had been very interested in his remarks, particularly in the experiment of initiating rate-fixing in the tool room. Some years ago he had adopted a similar method, although he did not go so far as to say they paid the tool-room men the bonus they earned. What they had done was to adopt a general card system by means of which cards were issued to the foremen concerned, and the foremen were expected to show the operators the cards. His difficulty, however, was in dealing with non-standard, intricate jigs such as those they had in the motor trade, and it seriously crossed his mind as to whether it was really a paying proposition to attempt to fix prices for such tools. The difficulty was to know, within a degree of certainty, how much time would be necessary for lapping, scraping, and accurate fitting operations. He had come to hear the paper, fully expecting to go back to his own works, which was a non-repetition factory, and knock spots off the production of non-repetition work, and was even hoping that he might get a rise of salary at the end of the month, but, with all due regard to Mr. Armitage, he could not see that he had touched on the essential point that was going to help them materially, in the rather small quantities which they handled. He agreed with Mr. Gartside with regard to the question of design and production, but he also thought it was time there was more co-operation between the designer and the machine shops. He had seen many cases where slight alterations in design to facilitate machining methods had increased production. Designers, as a rule, went ahead without finding out just what fixtures and tools were already in the shop, and there might be lying in the tool stores a fixture costing £200 which with a little thought could often be made use of in formulating a new design. This trouble arose in almost any engineering shop one cared to visit, and they were up against it in their own design office and manufacturing departments.

MR. ARMITAGE said that many of them had mentioned oscillation, and he had been censured for not having shown members how to cut their costs in half. When he had written the paper he was not any more satisfied with it than some of his critics, and he could assure them that it was very difficult to put down on paper ideas which could be made applicable to any or every particular works. As a general principle, however, he had endeavoured to show that manufacturers thought in terms of one component in particular, whereas the general engineer was frequently burdened with the idea that he could not obtain repetition and was, therefore, unable to apply manufacturing machines or methods. Now the purpose of the paper was really to show that manufacturing methods could be applied in a limited degree to non-repetition work, and that there is no reason why they should not be applied a great deal more

than is the accepted view. Possibly the oscillation trouble arose from the fact that the paper had necessarily been abbreviated, and it had not been possible to circulate advance copies. When they came to read the paper he thought they would probably be able to see the distinction between repetition and non-repetition work, because in every case he had been particularly careful to state when he was referring to manufacture and when he was speaking about general engineering work. Moreover, he had tried to define general engineering at the commencement of the paper.

With further regard to the question of the design department and the works office. In every works there were two or three departments which were almost hereditary enemies. One would always find that the drawing office and the works office were liable to criticise one another, and perhaps the works and the drawing office very seldom got on well together. Still, he thought it was the practice in the majority of works nowadays for designs to be reviewed by one of the producing departments prior to putting them out into the works, and that was done so generally that he was rather surprised at it being mentioned at the present time.

One of the main points which he tried to make and which no one had criticised was the fact that in a general engineering works particular attempts at organisation should be put forward for changing jobs from one machine to the other, and pulling a machine down and setting it up on another job in a systematic manner.

Further, he had tried to show that planning was far more necessary in a general engineering works than in a manufacturing works. He had not been criticised on those points, and would welcome discussion on them.

On the question of tool-room costs, it had to be borne in mind that they were dealing with skilled men. It would be found in factories where a piecework system was adopted in the production shops that trouble arose in remunerating the skilled men. They were dissatisfied when they found unskilled men earning far more than they were able to earn. The fact remained, however, that in the tool room they had been able to lay down a time for every job, and, as a result, found an increase in output. The tool makers had been led to ask for piecework themselves and it had therefore been introduced.

Mr. E. W. Hancock, Member of the Council, said that he agreed with Mr. Armitage's remarks in connection with the application of the flow principle of material to outputs, whether they be large or small, and in this connection he agreed that some form of planning should precede any machining, whether it be for repetition or general engineering work.

He also said that, as a point of interest in dealing with general machinery, after checking the sequences of operations on similar

classes of work, he had found that machines could be arranged in the line sequence, although in sections.

With regard to the relationship between designers and production engineers, he pointed out that the production engineer, since he is an engineer, is able to study the designs and appreciate the requirements of the designer, as well as, on the other hand, having knowledge of the machinery and conditions available in the producing areas.

Therefore he automatically had the advantage of seeing both sides of the picture, and, providing a suggestion for modification of design did not in any way affect the ultimate functioning of that design, and providing the designer himself was agreeable to make the change, he, Mr. Hancock, did not see any reason at all why such a modification as this should not be introduced. He thought that this method of interchanging ideas was a good step towards the solution of that vexed question of co-operation between the design department and production engineers.

This question of design modification refers only to details, and he was fully in agreement that the designer should be given as much freedom as possible to develop more advanced ideas, and that the production department should in no way interfere with the development of improvements.

On the question of conveyors and trucks, he thought that some form of roller conveyor on the main lines, and for handling heavy items, was quite satisfactory, but he thought that for dealing with batches of material, which are inevitable even on reasonably high production, the use of electric trucks, efficiently organised, could be satisfactorily introduced, and would also have the advantage of keeping the shop free, should modifications or rearrangements of machinery be required.

He pointed out that he did not in any way suggest that he was opposed to the idea of mechanical conveyors, as working on a product which was absolutely "cut and dried," and providing the quantity was sufficient to justify them, conveyors were the most satisfactory means of handling material.

Mr. Armitage, referring to the advantage of conveyors against trucks, said that if they had an excellent floor all over the factory then trucks were undoubtedly an advantage. If they had not, then it was far cheaper to put in a conveyor than to put in a wood floor.

With regard to the grouping of machines, suppose, for example, it was impossible to obtain repetition in any form, then one must endeavour to classify and standardise against operations instead of parts. Almost all machinery involved the use of pulleys, gears, and shafts, together with heavier parts, such as cylinders, etc. Everything from the foundry of a round nature should go into one department. In the machine shop everything requiring turning and boring would go to a boring section. Work requiring the

boring of holes of all sizes and shapes would immediately go to a department devoted to nothing else but boring holes. In such a department it would be possible to have a group of boring machines which would immediately tackle any size of hole or any class of work within the range of manufacture. The essential thing was that the holes should be standardised instead of the tools, so that, for instance, immediately it was necessary to arrange for a 1⅛in. hole to be bored the operator simply got out the equipment for a 1⅛in. hole, made the necessary adjustments to the machine, and carried out the work according to a standardised method. When this was done the work passed on, say, to a mandrel section, where there was a set of tools for pushing mandrels into the various standardised holes, and after that it was passed on to centre, or whatever specialised lathes might be required. The point was that although it was non-repetition work it was possible in this way to obtain conditions similar to those prevailing in a repetition shop.

Mr. Gerard Smith, Member of Council, said that he did not think there had been any oscillation, but the trouble was the loose way in which we engineers use our terminology. In speaking of a non-repetition shop and a general engineering shop many of them were thinking of entirely different things. For example, if he were not mistaken, Mr. Armitage mentioned that it should be possible in a general engineering shop to plan three months ahead. He would like to ask Mr. Gartside if they could ever plan three months ahead in their shop? The very nature of the work made it absolutely impossible. The last order was generally the most important. He thought planning was correctly understood, but in the general engineering shop it was so extraordinarily difficult. The work may be planned ever so carefully, and the next week something came which upset the whole plan of the shop, and, whether one liked it or not, one had to adopt a hand-to-mouth method. The best machine for boring a particular hole might be set up already on a job which was going to take six hours. It was impossible to wait, therefore a less efficient machine must be used. He would very much like to meet anyone who had really adhered to any sort of planning system for one week on end in a general engineering shop.

Regarding the question of design and production, many a time at their meetings he had advocated the works meetings, and many a time he had been criticised. But we have now got half-way, inasmuch as we took the designer to the shop, or allowed the shop people to criticise the design. Why should not the production man see what he is to make and criticise it? Why should not the inspector be able to see what he is to inspect They had things to deal with that were practically uninspectable. In the costing department the poor fellows did not know what they had to cost before it came along. They had no idea what a thing ought to

cost, although they were expected to give a reasonable report upon it from the financial point of view. If it were proposed to take the work to the various people concerned, why not take all these people into the same room and let them discuss the whole matter. Record the minutes of the meeting, and there was then something everyone had to adhere to, and the hereditary enemies by constant touch might become hereditary friends.

On the question of cost reduction, it appeared that the more general the shop, the more true it was that the selling price of the article was what could be got for it, and there were many cases where the factory cost and the selling price had absolutely no relation to each other.

He was amazed at the figures given on the question of tool room efficiency. He did not wish to be rude, but it seemed to him that the big increases obtained might have been on account of previous gross inefficiency. His own experience of trying to introduce piece work in the tool room had not been very successful. The difficulty was to determine what should be a fair price. He would also like to ask Mr. Armitage whether, in arriving at the cost of the piece rate method, they had taken into account the large amount of drawing office time, and planning and progress time which would be extra to the wages of the foremen whom he had mentioned.

MR. ARMITAGE, replying to Mr. Gerard Smith, said that in the matter of planning three months ahead he thought that they had got confused ideas as to what was meant by planning. Planning, as he had said in the paper, was twofold. First, there was the central planning department which dealt with the general planning. When they had fixed their calculated prices in the central rate-fixing department, some sort of adjustment had to be made in the works for the varying conditions which were bound to occur. Exactly the same thing applied to planning, because what was wanted first to-day might be wanted last to-morrow. A letter from a customer, for instance, might mean having to give priority to his order. The planning department attended to all this by a process of rearranging priority cards. That was part of the whole scheme of planning, to carry out this rearrangement systematically instead of the erratic manner in which it would otherwise have to be done.

On the question of works meetings, these were generally successful, although it all depended upon how the works were run. His experience of works meetings was that they slowed up decisive action, but they certainly avoided serious mistakes. On the whole, he thought it better to put the responsibility on one man rather than to share responsibility for everything on everybody in the factory. This frequently happened with administration by a meeting.

He agreed that costs and prices were fixed on what could be got for an article. He happened to be in a position where he often had things put forward with the price they cost. He knew perfectly well that in the majority of cases the prices were what the man thought he could obtain, and if one told him that he would not get that price, he trimmed it and gave one a price approaching more nearly to the proper figure.

With regard to tool room costs, he had given the total figures, and there was no doubt about the economy of the piece work method. They regarded the tool room as a separate entity from the remainder of the works, and the overheads had not been increased in proportion to the work turned out. That is, they had maintained their non-producers in the tool room at the same ratio as previously.

MR. MANTELL, Member, referring to the question of grouping the machines, and works transportation, said that it might be " He rushed in where angels feared to tread," but he disagreed with Mr. Armitage when he said that the line system of production was not suitable for a small works. Later on another speaker had remarked that, of course, no one in the room would agree with the line system of production in a small works, and he (Mr. Mantell) began to feel very small, because, from the paper, he had thought it might be possible to use the line system to advantage in quite a small works. Mr. Armitage had mentioned that general engineering works in any case were only general in that they turned out one or two things at a time, and whatever they produced was in a general class. As an illustration, he would take air compressors. There were several small firms making these in this country. In an air compressor there were quite a number of small components which could be standardised, and no doubt turned out on the group system to advantage. Also there were very heavy components which would require quite a lot of handling, especially if one adhered to the grouping system of machining. With the line system, however, within certain limits, from the smallest to the largest compressor, these components are handled on the same machines, and if these heavier components were taken down a line quite a lot would be saved in transportation. It would be interesting to hear other views on this subject.

In talking of transportation, mention had been made of trucks and convevors. He thought all of them received from Herbert Morris, of Loughborough, very interesting little booklets; so far as he was concerned, Herbert Morris sowed good seed, and he thought the overhead runways described in his latest booklet would overcome the mountainous ranges which Mr. Gartside had to contend with. Floor space was generally very valuable in a general engineering shop, and this was saved by means of a runway.

As far as design and production are concerned, at previous

meetings he had said what he still considered to hold good, namely, that the production engineer should follow out the designs which were sent him from the drawing office unless there was some radical reason for departing from them, otherwise progress could not be achieved.

As far as standardisation of parts was concerned, he knew one firm in the United Kingdom who approached this subject in a very thorough manner, and they found they were making bearings of several different sizes for a range of machines, and there were different specifications on each line of manufacture, so that in all they found that they had 120 different sizes of bearings. Further analysis revealed the fact that each bearing had been evolved because the designer sat down and calculated with mathematical precision his requirements for the unit being considered. It occurred to them that if they put bearings on the 1½ h.p. unit similar to those on the 3 h.p. type, they would probably be using a little more metal, but they would be effecting a great saving in work in progress and stores, apart from which production was assisted considerably with greater efficiency all round. For instance, all bores were finished by broaching, and big economies resulted.

One other point Mr. Armitage mentioned related to bolts, nuts, studs and various minor details. These things " just happened " and received very little serious thought, and it would be a very good idea (it was done in some works now) if a list of these fittings was drawn up and issued to draughtsmen. In one or two works of which he was aware, the sanction for making special parts was very difficult to obtain, and the draughtsman had to justify his case right up to the hilt before making any departure from the standard lines.

Mr. Rich, visitor, said he would like to ask a question arising out of the facts and figures which Mr. Armitage had given regarding piece work in the tool room. He would like to know the percentage of mistakes or underestimates that the rate-fixers made. As everybody was aware, tool room work was very difficult to estimate, and he would like definite information from Mr. Armitage as to whether the times were fixed before the job started, and if they were altered during the course of manufacture.

Mr. Gartside interposed, and said he would also like to ask how this question affected the tools. Rate-fixers did not lay down the tools, but this was done by someone else in the office. It was also said that rate-fixers were good at guessing times. He would like to know whether there was any guessing behind the times laid down.

Mr. Armitage said that he rather anticipated that the matter of piece work in the tool room would be interesting to everybody. They certainly did not undertake tool study or motion study of

the tool makers. Whatever quantity of any part had to be handled, the amount of time that could be economically spent in fixing a price on a job must obviously be in strict proportion to the number to be produced. If there were a thousand off, one could afford to spend a fair amount of time in arriving at the piece work price, but with a tool room it was not really of great importance what actual time was given to the tool maker. As a matter of fact, the actual cutting time on a job was always small in proportion to the preparation time, that is, the time for rigging up tools and making settings during the operation. There was not a lot to be gained, therefore, in calculating feed and speed times. A simple system of operation planning is adopted, and a time is actually put on the operations before the work goes into the tool room. Under ordinary non-planned methods it would be found quite a regular thing in the tool room to get a job about two-thirds completed and then discover that they had set about the job wrongly, due to the fact that the foremen of separate sections in the tool room had each done what they considered to be the right thing, although when it came to be assembled it would appear that in some cases it would have been better to have partly assembled before finishing machining. Anything like that was obviated by planning the work beforehand, and afterwards putting a price against each of the planned operations in the tool room. The same thing could be applied to jobbing work, and that was why the tool room had been particularly mentioned in the paper.

The question of the line system *versus* grouping of machines had been mentioned once more by Mr. Mantell. Wherever the line system could be adopted this should be done, and if it were possible to obtain any sort of similarity between the various component parts it would pay to run them down the line, because the same classes of machine could handle the various sizes and parts.

Mr. Whitaker, Member, said he had left his remarks until rather late as he had been trying to separate the subjects of quantity production, semi-quantity production, and small quantity production. It seemed to him that the vexed question of fixing tool room prices was largely dependent for its success upon quantity production, where actually the cost of the tool was not of such vital importance. If they were dealing with very small quantities, surely the whole question resolved itself into the comparative cost of producing the separate items or units with or without tools. Some of the tools for small quantities had to be produced to a very high degree of accuracy. Some of them for purposes of manufacturing facility were produced to a very low degree of accuracy, and it became more difficult to fix a satisfactory price for manufacturing such tools. It seemed to him, if a near guess were given it would be futile. The last remark also applied to the handling and planning of various parts for small quantity

production, and unless they continually estimated what the comparative cost was going to be with or without tools they could not decide whether to have tools made for a part or not. If the estimates were exceeded in any way, the desired saving might resolve itself into a loss.

MR. PATTINSON said he hoped he would be excused for bringing up the matter again, but he was very interested in it. All along, those engineers who had been in the shop had always realised the importance of what they considered to be true time study and rate-fixing. It had always been his practice that any time studies or rates that are fixed should be subject to actual demonstration in the shops, and in his opinion no rates should be accepted as final until it could be substantiated in practice. If they would excuse the term, he thought that guesswork was damnable. He did not see how it was possible to put rate-fixing on a satisfactory basis in the tool room. He was in the habit of comparing his tool room prices with those outside, and they did not make tools in the tool room unless they could produce them more cheaply than they could buy them. He certainly could not see how they could take men out of the tool room and let them fix prices for their mates and then obtain a tremendous increase in output unless careful and scientific time studies were made. He knew what the feeling was in the shops regarding payment by results, and he thought the quicker they eradicated the nasty feeling that they were out to twist the men and to get the last ounce out of them, the better they would be. This was why he did not think it right that times should be fixed by guesswork, as it was not conducive to good feeling in the shops.

Mr. Armitage said there was a great difference between a well-informed guess and an uninstructed guess. A man who was continually in touch with the relationship between work and times and prices could state very easily what length of time a job ought to take with sufficient accuracy for short runs, or even single pieces which were handled in a tool room. There was a general similarity of work all through, even in the tool room, and there was not a great variety of operations in making jigs; and what was found in practice to be a reasonable time on a job on one occasion would hold good on another occasion. If times had to be demonstrated for every article handled by the tool room overhead charges would increase to an impossible extent. In his opinion a simple form of rate-fixing was sufficiently near for practical purposes in a jobbing shop or in a tool room. Where there was a large run of work, obviously it was not sufficiently accurate, and prices must then be based upon the facts obtained from time studies. Time studies in the tool room were impracticable.

MR. PATTINSON said that was why he wished to make clear that bonus in the tool room was not a paying proposition unless one kept to standard work.

MR. GARTSIDE said that he knew one particular works in this country before the war who had introduced piece-work for making jigs. He did not refer merely to bushes or jig plates, but to complete jigs. It was impossible to find more accurate jigs than those referred to. Now he knew that that tool room was for many years on piece-work, and through constantly coming into contact with the men he always had a feeling that they were not satisfied. Sometimes a man would say, " This is a grand paying job." Then the next one would be a badly paying one, showing that the rates were largely guesswork. He did not mean guesswork as a man out of the street would guess, but a guess by making comparisons. He thought there were possibilities in the method, and, taking one job with another, one could make a fair estimate, but one needed a large amount of experience to do it, and he thought Mr. Armitage was on the right track in taking men out of the tool room for rate-fixing. Of course, the foremen would have to see that these rate-fixers did not give too high a price, and if Mr. Armitage had managed to make 25 per cent. extra output, that was in his favour. There was something in the saying that " what they had lost on the roundabouts they had gained on the swings."

MR. WHITAKER said that with regard to estimating for tools he would not like his remarks to be interpreted to mean that it was not possible to estimate fairly nearly for tools even on non-production work, because a matter of sixty or seventy tools per week going through the tool room could be estimated to within 10 per cent. of their actual cost, and he had found that to be so in practice.

MR. STOREY said he had tried piece-work in the tool room for some years. He could not say that he had found any extraordinary saving. As a matter of fact, he wondered at times whether to stop it, but had decided that a saving, which was not apparent on paper, was effected, in that the tools came out very much more to schedule. For rate-fixing the operations had to be planned, and hence special requirements in the form of tools and master plates were thought of, and thus very much sweeter running of the work through the shop and a slightly higher output was obtained, due also to the fact that the tool room foreman had to waste less time on the planning of the work.

With regard to " guessing " of piece-work times, he thought that a good man could guess extraordinarily near. As a matter of fact, there was not much difference in time, taking a $\frac{1}{2}$in. bush and a $\frac{3}{8}$in. bush, except a few seconds more in turning. Now, the average jig consisted of a strap and a few bushes, and, unless

there was some elaborate angle setting, the times taken did not vary greatly. In boring a jig, for example, it made little difference whether the hole was ½in. or 1in. The time taken for setting and moving the work over was approximately the same, and, after tabulating and watching such times in the shops, an accurate "guess" could be made in a few minutes. The item that would help most in the elimination of human effort was standardisation.

Mr. Mantell had mentioned the standardisation of bearings, and it seemed to him that instead of making one size of bearing for a range of machines it would be better to cut out the intermediate sizes of machines. He found by calculation, and also by actual experience, that a 3 h.p. compressor could be made for about the same price as a 1 h.p. machine, if only one size (the 3 h.p.) be concentrated upon, and he did not think many people would object to having a 3 h.p. compressor if they could get it for the same price as the smaller model.

MR. MANTELL said that the figures he had quoted were only by way of illustration. He would like to say one thing more. With regard to the question of fixing prices in the tool room, the chief objection raised seemed to be that men were going to earn too much, and he felt confident that this attitude was the cause of a lot of the suspicion towards piecework which previous speakers had deplored. Any job, when it was quoted upon by an outside supplier was estimated in some way or another by taking into account drawing-office expenses, material, labour, and overhead. It must be analysed before a price can be quoted, and one must have a rough idea as to how the price is made up, therefore he failed to see the insurmountable difficulty of arriving at a piecework price. Surely it is better for the employer, if twice the amount of work is turned out for the same overhead, even if the employee walks out with a double-pay envelope.

MR. ARMITAGE said that as far as the discussion had gone with regard to piece-work in the tool room mention had not yet been made of outside prices. He might say that previous to introducing piece-work in the tool room they bought dozens of different small tools outside. Since introducing piece-work they had been able to produce such tools at approximately 75 per cent. of the outside cost, and this was additional work that they were doing in the tool room. It was very clearly established that they were able to do it against outside prices.

Now with regard to estimated costs, surely if anyone could estimate for a thing they could fix piece-work prices, even on the basis of their estimate. There were firms who did nothing else but tool making, and if they could not estimate their prices and also estimate piece-work prices, they were not likely to exist for long. He was pleased to find that one, at least, Mr. Storey, was in agree-

ment with him, and what he had found with regard to tool room piece-work exactly coincided with his own experience.

MR. HUTCHINSON said that there was just one point on the vexed question of piece-work in the tool room. He had had experience of this for well over 15 years, and it could be worked perfectly satisfactorily. At the Vickers works at Barrow everything was done on premium bonus, which, as far as fixing times was concerned, was the same as piece-work. All times were given by the rate-fixer on the floor of the shop, and it was very seldom that a serious mistake was made. One had to realise that a man who never made a mistake generally took too long over his work, and was not therefore an efficient employee. Generally speaking, where one had men that were constantly handling certain types of production, these men could with experience tell within a very narrow margin how long a job ought to take, and no one would call that kind of estimating guessing.

Probably one point which had been brought out and stressed by the discussion was the saving in the Austin tool room. One had to realise that the Austin works was essentially a repetition factory, and if they were employing 9,000 men on repetition work they must be using small tools, and even some of the larger tools in fairly large and regular quantities. Therefore, the tool room itself must be doing a lot of what could be termed repetition work. Probably, if they were to differentiate between purely tool room work and non-repetition work they would not actually have saved very much money, possibly not much more than the wages of the four men, but at least they would have a contented staff of tool makers. Unfortunately, in London it was difficult to get tool makers to work on piece-work.

Then there was the matter of conveyors. He thought Mr. Armitage had hit the nail on the head when he said one must realise what is suitable for one works was entirely unsuitable for another. He did not think a works manufacturing compressors in small quantities should be termed a general engineering works. His conception of a general engineering shop was one manufacturing a large variety of articles, and those articles in themselves of very varying types. Take a factory manufacturing steam turbines. These were made in a variety of types with a large number of different frames and sizes. The reason was that turbines must be designed according to the available space, the steam pressure of the boiler plant (if same is existing), and to suit many other conditions which must be taken into consideration. A turbine of a particular rating may, therefore, differ in many respects from a similar one of identical rating supplied only a few weeks previously. In other words, it was impossible to standardise the main portions of the work on plant of that nature, and that in his opinion describes the principle of a general engineering works,

i.e., where it was necessary definitely to fulfil customers' requirements.

In dealing with the subject of conveyors in a general engineering shop, it must be realised that one could not necessarily send all round work to a turning or boring section. Quite possibly some of it would have to go to a planing or milling section prior to boring, or it might have to go to other departments first. That was why he could not conceive of any conveyor system which was generally applicable to a general engineering shop apart from the travelling crane.

In conclusion, he could not help disagreeing with Mr. Gerard Smith once more. He did not believe in works committees. If they had co-operation between departments committees were entirely unnecessary. It should be possible, and it was an advantage, that all heads of departments who were responsible for the various sections of the works should be in constant touch with each other, and the subordinates in one department should be in touch with the subordinates in another department. If that kind of thing were encouraged and a good spirit were fostered between members of the staff, it was infinitely better than introducing works committees, which he did not think brought about a better feeling. His experience was that they very often brought about very bitter feeling between the people concerned.

He thought they had had a very good paper and a very good discussion. He was rather pleased that the discussion had not really been of the nature of patting Mr. Armitage on the back. This invariably means, in his opinion, that people had appreciated the paper very much more, and it had been more interesting, and he thought they all felt very grateful to Mr. Armitage for his paper.

EDITORIAL.

(November, 1927.)

AT our first Annual Dinner Sir Alfred Herbert asked "What is the Institution of Production Engineers?" Our presidents of the pioneering era and the members of the Council must feel gratified that the answer to that question, not given in words but exemplified by deeds, proved so satisfactory that a man, so busy as Sir Alfred must be, has consented to become our President for the Session 1927-28.

None will dispute the debt the Institution owes to those who have preceded Sir Alfred Herbert. It is due to their guidance that it has acquired a reputation which justifies the new President in linking his reputation to that of the Institution.

With quiet confidence we can assure anyone, however eminent in the engineering world, that they can safely follow where Sir Alfred has led; first as members, thence, if fully qualified, to higher office. It should be observed that we say: ". . . if fully qualified." The Institution has not and, we hope, never will lower its dignity in the effort to associate with itself a title *per se*.

In Sir Alfred Herbert we have a man of almost unique qualifications. His manufacturing activities alone are sufficient, but to these have to be added his exertions as a machine-tool merchant. Although a manufacturer of "instruments from which production engineers draw sweet melody," as he himself describes his products, he has the breadth of mind to scour the world in an effort to bring the best equipment into British shops.

It is the diversity of experience which his many activities must have brought him, which we ask Sir Alfred to place at the disposal of the Institution, and, above all, we look for assistance in a task we must set ourselves: that of attaining peace in industry.

A movement, be it political, social, or scientific, can only live so long as it renders service to the community in which it has its being. The Institution of Production Engineers is now national in extent, and its responsibilities begin to be heavy. Up to the present internal development has demanded all its energies; in the process, some grains of usefulness may have been vouchsafed the wider world outside, but its services to the nation have not been of such a character as it is now capable of rendering.

In looking round for a useful field we are impelled to the thought that, before our technical abilities can be given full rein, we must enjoy the conditions which make for unhampered progress.

Reference is made to the slogan " Peace in Industry." With many it is only a phrase, a political expedient, something to soothe a probable voter or to calm an irate shareholder. To us it is a vital necessity, something without which our best efforts are rendered valueless. Let no man deceive himself that the era of comparative peace we now enjoy is the real thing. It is not, it is only the peace of exhaustion—an armistice. How then to translate the apparent into the real? From the plethora of speeches and writings on this subject, two stand out.

Robert Williams, in an article in *Answers*, has enumerated the factors which must be examined; that is, instead of expressing a pious hope, he has brought the subject down to a basis for practical examination. Not only does he castigate the employers (not, be it noted, as " bloated capitalists " but as inefficient managers), but he censures the employees for failing to render that for which they are paid.

The other contribution of note comes from Sir Alfred Mond, who, at the Peace in Industry Conference, held in London on October 17th, suggested an organisation on the lines of the League of Nations. This, and his recent utterances pointing out that co-partnership should not end in profit-sharing, but should extend to co-responsibility, are suggestions we, as an Institution, should seriously consider.

The remarks we have quoted are from men who exert considerable influence, yet a wide gap still exists between the branches of industry they represent. The members of this Institution, in their work, have for long been the means of communication between those branches, and, more than any other body of men, have a wide knowledge of the aims and, more particularly, the trains of thought which sway the opposing forces.

The Institution is waiting to place the experience so gained at the disposal of industry. Will industry accept?

THE CONSERVATION OF HUMAN EFFORT IN INDUSTRY.

A Paper presented to the Institution on December 15th, 1926, by E. C. Gordon England.

IN submitting the following remarks to you for your consideration, I have had in mind a conception of the production engineer, which may or may not be the one generally held as the true description of his function in the scheme of Industry.

So, for the sake of making my point of view clear to you, I am going to give my definition of what I conceive to be the function of the production engineer, and in the discussion that will follow no doubt your chairman will give you ample opportunity to turn and rend me if this definition is distasteful to you.

I submit that the function of the production engineer is to direct the human units placed under his control in such a manner that the greatest possible production is returned for any given amount of human effort expended.

You will observe that in this definition I have made no mention of machinery, or what are called efficiency methods, as being part of what has to be directed, and my reason for this is that these things cannot be "*directed*"—they can only be "*used*" by those under the control of the production engineer, and are purely accessories or tools.

I wish, with your permission, to labour this point, because to me it is the essence of the whole matter.

As far as my experience and information go, the general conceptions of the functions of the production engineer are that he is a man who is skilled in the use of machinery and efficiency methods, and by the application of this specialised knowledge is capable of extracting a certain amount of human effort out of an unwilling and unintelligent mass of humanity.

My submission to you this evening is that this is an entirely wrong view, and that the present general acceptance of this view is in itself one of the chief reasons for a major portion of the difficulties with which the production engineer is faced.

Nothing could be farther from the truth. The production engineer's true function is to manage and direct human beings, and his first care should be the protection of these human units.

Let us now examine the purpose of Industry, as that will enable us to view things in a truer prospective. What is the purpose of Industry? Surely, to provide goods, commodities, com-

forts and luxuries for the peoples of the world, ultimately at such a price that they may be within the reach of all.

The accomplishment of this end cannot be effected without making substantial profits in the course of its achievement under the existing social order.

In other words, Industry is and must increasingly become the essential service to humanity, and since the mass of humanity is and will be engaged in Industry, it would seem logical to say it follows that all human effort should be used with care and sparingly, as any waste must be against the interests of the mass of those engaged in Industry.

Looked upon from this angle, it will be agreed that production engineers are trusted with great responsibilities, and that they can perform a great service to humanity by the proper observance of their trust and its efficient operation in the world of Industry.

I hold the view that the profession of the production engineer will become one of the most important and highly respected professions in the world.

May I say at this point that I am forced by the limited time at my disposal to condense this vast subject into a few words and to appear somewhat dogmatic in order that we may make some progress with our subject.

Our proposition now stands that the purpose of Industry is to minister to the needs of humanity, and in consequence the production engineer is responsible for the conservation of human effort engaged in Industry, as on him rests the responsibility to obtain high productivity at low cost of human effort.

You see how easy it is? All the responsibility is upon your shoulders, and upon that point I am sure of your agreement. Every production engineer takes all the responsibility and none of the profits!

We will now consider this my view of the function of the production engineer, and I hope I shall survive the discussion, because I am going to state quite unequivocally that every production engineer has got to accept as a fact that his greatest responsibility and duty is the saving of human effort, and not the application of machinery and efficiency methods except inasmuch as they contribute directly to the better utilisation of the available human effort.

Human effort is the only priceless commodity at our disposal, and yet we squander this valuable commodity as if it were of no consequence.

We spend an immense amount of effort upon the production of better and better machinery, and we give a great deal of thought to the better use of machinery and plant at our disposal. One can buy a host of valuable books and other literature on the subject, and pushful and purposeful salesmen will worry you day

in and day out with efficiency methods; but how much literature is available to you on the subject of the study of the human element in Industry? Where are the pushful salesmen who will show you how to turn a farm hand into a tool maker in 12 lessons only, or give you the sure method of selecting only first-class and exactly suitable hands for all and every job?

Until quite recently very little literature and no salesmen were available, but there is now an increasing appreciation of the view that the human element is the factor of prime importance.

To put it quite shortly, I submit to you that you must for the future look upon your workpeople as the governing factor in your works, and lay all your plans so that every action you take will definitely promote their true welfare and conserve their efforts.

It is safe to state that in a very great many industrial concerns the labour element is always taken as the basis upon which all costing is based, and the eternal struggle is to cut down the labour element in that cost.

This in itself is correct, but too often the true reason for this cutting down is lost sight of, and the error of assuming that this cutting of labour cost per unit produced is the ultimate end makes people assume quite incorrectly that what is intended is the elimination of labour in Industry, not its conservation.

Might I ask you to ponder upon that statement, for although it may seem the same thing, there is a vast difference. Our purpose in Industry is to employ profitably more and more people.

In other words, the objective must be the greatest productivity per human unit, and not the reduction of human units engaged in Industry.

To attain this end, many difficulties have to be overcome, and at the present time the chief one is the attitude of the human units themselves as expressed by the policies and actions of many Trade Unions and Employers' Federations.

There is undoubtedly on both sides the idea, and it is held quite widely, that real prosperity can be achieved by restrictions and trusts. This is the natural outcome of muddled thinking—the result of not having a true conception of the ultimate object of Industry as a basis for the thinking.

It is very seldom appreciated the great speed at which our industrial knowledge and organisations have advanced and are advancing, and it is a serious difficulty to contend with in that humanity cannot adjust its thoughts, actions, habits and mode of living to synchronise with this advance. Mass thinking and consciousness has a great moment of inertia to overcome, and it is because of this that these so-called protective associations and national legislation are often a bar to swift progress.

These forces are of considerable magnitude, but that fact does not permit us to take up the attitude that they form insur-

mountable difficulties in our path. We should rather, having realised their existence and magnitude, have no excuse for failure to overcome them in due course.

Great as these difficulties are, they will yield to reasoned argument and practical demonstration that there are better ways of attaining the desired ends than those at present in vogue, because it should be clearly realised all the time that the mass of the people are moved by the same motives, and are all, in fact, striving to attain the same end for their particular group, family or self, that is, a fuller life (I use the expression for lack of a better one), and this is true in spite of the seeming insurmountable clashing of interests.

You will have gathered by this time that I am a hopeless optimist, and have great faith in humanity. I am an optimist, and I hope I shall long remain so, as I cannot conceive progressive and constructive thinking without it.

Production engineers must be optimistic, for their belief must be that all difficulties can be overcome if tackled upon a proper basis.

Having now sketched, I admit, a very light draft of the proposition and nature of difficulties which prevent its fulfilment at present, I will turn to the consideration of some of the directions in which human effort is squandered. Here again I can only mention a few of them, and try and suggest the basic lines upon which we may perhaps conduct our plans for saving this lost effort.

Walk round any factory or business, and you will find that a large number of people, on what is usually known as " the staff," are being forced to waste time through the observance of rules and regulations as to conduct, demarcation of duty and responsibility which are quite unnecessary. There is lost effort due to quite unnecessary control and supervision, and so on. In the workshops you see the same thing, but perhaps in a more complicated form.

In how many offices could one find, for example, by individual examination, a high percentage of the staff who could pass the test of being able to set down on paper their duties and responsibilities, and their relative positions to those just above and below them in their department. I doubt if many of the higher members of the staff would make a good showing, far less the rest. What a waste of effort must result from such a state of affairs, and what a chance for education on the right lines.

Again, in how many firms will you find the attention of the Board of Management directed to the item of labour turnover both in the staff and the rank and file? I know of very few concerns where this item gets any consideration at all.

Yet here you have one of the very worst causes of loss of human effort.

You take a human unit, teach that unit certain things, time is given to this and the equally important stage of settling down to the new job, both inside the factory and outside, all of which represents a capital investment in that unit. You cannot overlook this point of settling down, for whether you have appreciated this in the past or not, the time it takes a new member of the staff to settle down in a new home among new friends and acquaintances *outside* the works is all reflected in a lowered output at work until these things have ceased to be a preoccupation.

Yet, in spite of this, it is fair to say that the engagement and discharge of personnel is considered to be just a matter of expediency in a great many concerns to-day, and the capital invested is written off without thought. Think of the waste of human effort that this represents.

Working conditions in office and factory are again the cause of much lost effort. I find, in the course of my investigations, that the standards of ventilation, heating, lighting are very low if taken over a large number of different concerns of all sorts and sizes.

Food, sanitation and general matters of cleanliness are far from being matters of real concern to many boards of management, even to-day.

Yet who is there among my audience to-night who can truthfully say he is unaffected by any one of these factors? They are vital to human effectiveness. Many of those here to-night have had experience of the difficulty of getting sanction for expenditure in this direction.

I want you, if you will, to agree with me that I have justified for our purpose this evening my contention that there is much waste of latent productivity in human units, so that we may now consider the problem from a somewhat different aspect, as this will help us to get a more businesslike view and assist me to convey to you the reasons for my conclusions.

I want you to accept from me the proposition that every one of us, from the highest to the lowest, of those engaged in Industry are nothing more or less than machines. Very wonderful machines, it is true; but none the less machines.

Now, when we purchase or hire a machine—and here I mean any inanimate production of man—those of us who know something of our business set about it somewhat in this fashion.

Firstly, we hope for a productivity in advance of what we are at present getting per unit of cost.

Secondly, we study the machines available in the market from every angle to see if this hope can be justified. We consider their general design, robustness, the overload they can carry, ease of control, maintenance, etc.

Thirdly, having satisfied ourselves that we have made a good selection, we purchase not on price but on promise of performance, and then proceed to plan its efficient installation so that it may give the best possible results.

Fourthly, having installed our machine, and started it working, great care is taken to protect it from unfavourable conditions, and to give it an ever-watchful and prompt maintenance service.

Fifthly, we study its working, and lose no opportunity to improve its production, and who among you has not been able very often by some quite minor adjustment of the working conditions of a machine, to get surprising results in the way of increased productivity?

Sixthly, we are properly careful of scrapping any machinery, and try and dispose of obsolete plant to the best advantage.

Now, why not deal with human machines on these lines?

Firstly, we can and do hope for a greater productivity than we are getting at present; and so,

Secondly, we should make a very careful study of all new staff, rank and file about to be engaged and pay particular attention to the fitness of the individual for the job; in other words, the general design of the human unit, *i.e.*, the mental make-up, the social status, physical condition and build, the past experience and training, and the exact suitability for the job in mind. Unfortunately, the sales literature given away with these human machines is usually of such a low order that it cannot be relied upon to give any real guide. It would, therefore, seem advisable to have expert advice obtained through personal contact. You have experts who buy machine tool equipment for you, so why not labour experts to act as labour buyers?

Thirdly, having made a satisfactory selection, do not be afraid to purchase on capacity for performance rather than price, as that is the real measure of value. In other words, do not be afraid to pay for good human machines.

We now proceed to the efficient installation of the machine, which means, see that this human machine is given such working conditions as will enable it to give the greatest output. Don't forget to provide suitable space for it to occupy. Remember how carefully the proper bed was made for the inanimate machine, so that it may stand well. In a like way study the seating position or standing position of the human machine, give it ample power or money to get the maximum output, give it good lubrication or food at the proper time, see that the working temperature is correct (how often this is forgotten)—the human machine requires a very definite working temperature to work effectively. Yet how often are workpeople expected to be fully productive with cold hands and feet.

You would not expect to work a plastic material successfully at any but one correct temperature. Why should you expect hands and fingers to be plastic and pliable at all temperatures?

Have cheerful and clean surroundings, so that the mind, that wonderful control box of this machine, may operate effectively. Environment has a marked effect on all people.

See that lighting is good and ventilation sound, as these have a great bearing on the speed and feed of the human machine.

Fourthly, protect the human machine against accident. See that first aid is always available—have experts watching the health of all units—see that good food is available, give tired workers proper rest periods, keep a careful check on working hours, see that proper holidays are taken. This means that you are not letting the machine be overloaded or letting a bearing heat up, or a defect develop into a serious breakdown.

Fifthly, study all human units at work. Have experts whose sole job it is to find better ways of serving work up to these human machines, so that there is less loss of time and effort. See that these people stand or sit to the best advantage, that the lighting is right, show them how to take less motions to accomplish a given movement. Make sure that you have got each unit used to the best advantage. Study temperament. You observe the ordinary machine to see if you can make better use of it. Teach them by every means in your power that all you do is for their good, and mean what you teach, because unless you mean it you will not succeed, and if you are a good business man, you cannot help meaning it.

Sixthly, scheme out a system whereby the human units who have accomplished certain work can pass on to other work that is better, or, when it is a case of becoming obsolete, find a suitable outlet for their failing efforts. There are plenty of jobs that could be performed by workers who have grown too old, if this matter received proper thought and was planned for well ahead. I am sure that many a worker who is too old for his job in the shops could be effectively used for office work. For example, if a definite plan existed to fit these people for such a job after their factory life was completed.

I hope I have said enough to prove to you that there is no doubt that it is a matter of good production engineering, and that means good business, to regard your workpeople as machines and remember that they are valuable machines. I believe there is a general agreement that the average capital value of the human machine is £12,000.

You will be wondering by now how I propose to take greater care of this valuable machinery, and see that all machines are running to capacity and so increase prosperity.

My suggestions are that we tackle the problem through education of the right kind. First of all, we must get agreement on all hands that human beings engaged in Industry represent the finest machinery in its sphere, and that it is, and must be, in everyone's interests that these machines be kept running to their full capacity and cared for and maintained in first-class order for business reasons, just as the successful do to-day with their inanimate machines.

I am convinced that if we approach people from the angle that we want to do all these things because it is " better business " to do so and cut out the semi-sentimental suggestion that it is what is known as " welfare " we should meet with less difficulty. I have found that people instinctively understand that " good business " means a favourable reaction for all parties, whereas wanting to " do good " has a favourable reaction in one direction only, and that not in the direction of the " done good to," if I may put it in that way.

To this end educational propaganda should be conducted by all production engineers; firstly, to convince the board of management how it must pay in results to deal with this human machinery upon a business footing; and secondly, to educate the staff, rank and file how it will pay them to regard themselves from this angle.

A great field is open for educational work in the proper training of apprentices. I suggest that in this direction a great work can be done to conserve human effort. Why not have a real course of training for all young people. I suggest that all young people should be trained upon a definite plan that would take into account the natural genius of each one, and so shape the whole course of training that at the end not only would the young mind have a good general grip of the whole trade, and so would be able to turn to and specialise upon any line in the factory, but would at all times be able to adapt himself to changes in productive operations, and not be thrown out of work.

Classes should be held to train the young mind in motion study, time study, material movement, machine tool, jig and fixture design, etc.

In other words, impregnate the young mind with the business value of these things, and you will find it a wonderful agent for propaganda.

I have found no great difficulty in getting individuals in many different walks of life, with whom I have discussed this subject, to accept this proposition once I have logically explained it; and having grasped this, they have soon been enthusiastic to co-operate in the real conservation of human effort in Industry.

The first essential step is to convince people of your sincerity of purpose, and outlook; if you accomplish this the rest is easy.

What is known as demarcation of labour must be broken down, as this is in itself one of the main causes of labour turnover and consequent loss of human effort.

I have shown that once a human unit has been engaged, capital is invested in that unit, and therefore every effort should be made to keep the unit within the organisation. If you have a machine that is surplus to your requirements in one direction, you do not consign it to the scrap heap without thought as to where it could be used or adapted for use in some other section. Every effort is first made to find a means of using it.

Your human machines should, as a matter of good business, be similarly adapted.

Explained in this way, much can be done with even the most difficult and hardened believer in the demarcation theory.

All labour should be completely fluid within an organisation and under the observation of human machine experts its transfer from one sphere of activity to another should be satisfactorily accomplished.

Proper systems of payment by result must be thought out because, as I have mentioned, wages are the power put into the human machine, and that power must be turned to full account or it will be bad business. More and more power should be applied as the capacity of the machine is gradually built up to maximum production.

This subject alone calls for many papers and much study. This can also be truly said of all the phases of this paper, so once again I would ask you to forgive the sketchy nature of many of the subjects touched upon.

I look with confidence to the time when all undertakings and people engaged in Industry will insist on the proper conservation of human effort in Industry, by everyone being made to take every possible step to protect and care for the human machine, and also see that each human machine gives the full return for the power put into it. The subject is so vast in its ramifications that I could only hope to touch on what I consider to be the main proposition in the hope that I shall stimulate you to follow up the matter from this starting point.

Great and wonderful opportunities are available to us all to make splendid advances upon the lines I have indicated, and there is no doubt but that those who grasp the truth and apply it fully, will find that their business will improve beyond their wildest dreams, as we have as yet not progressed very far upon the lines of the conservation of human effort.

But far greater than this individual gain will be the service rendered to humanity, which adds the touch of nobility to our accomplishments.

An Address given by Mr. C. R. F. Engelbach (Works Director, The Austin Motor Co., Ltd.) before the Birmingham Branch of the Institution of Production Engineers.

(September 28th, 1927.)

IN the first place, I should like to express my appreciation of the great compliment that your president and committee have paid me in asking me to be the first to address this newly formed Birmingham Branch of the Institution of Production Engineers.

You have started your Branch under very happy auspices. Your president, Mr. Hannay, is a man for whom I have the greatest admiration and who, in my opinion, is a production engineer in the truest sense of the term. Furthermore, he possesses the necessary strength of character and decision that will help your Branch to attain quickly that permanent position in your Institution which it undoubtedly will possess in the future.

You have a committee of thoroughly capable and practical men, at the top of the tree in their professions, with the requisite determination to lead you to success.

As I have not had the pleasure of attending any of your meetings in London, or in the Provinces, before now, I do not know if any of the remarks I am about to make have been amply covered in your proceedings, but, in any case, I trust that there is no harm in a repetition of facts which call for special treatment.

It is very difficult to define the functions of a production engineer, and the term itself was unknown to me before the war had brought production up to a much higher standard than had before been experienced.

I have, however, had the opportunity of reading some of the Institution's proceedings, and I see, with much interest, that a former president, Mr. Scaife, pointed out that what he termed manufacturing engineering had not received, as yet, proper attention at the Universities and Technical Schools, and with your permission I propose to enlarge on this subject, which I consider most important if we are to keep our position in international trade.

I prefer, however, to keep to the term production engineering as a more comprehensive one than manufacturing engineering, as production engineering consists of taking hold of a job from the designing stage to delivering it to the sales department ready to be despatched. In other words, there is both a technical and commercial side which comes within the scope of a production

engineer's duties. In very large factories these duties are even now sub-divided, and one can look to the future to still greater sub-divisions.

In the University Courses and Technical Classes a young man, who is proposing to become an engineer, is taught a variety of admirable subjects, which for general engineering have been chosen as the result of many years' experience, but which, as specialisation has become more and more necessary, in my opinion require revision, at any rate so far as production engineering is concerned.

I would suggest that a step in the right direction would be taken if your Institution would appoint an Education Committee, from your own members, to formulate, first, the definition of a production engineer, and then the early training he ought to receive. A syllabus could then be presented to the Principals of the Universities and various secondary educational authorities which would form a basis of training for those who intended to take up this particular branch of engineering. This syllabus would naturally include subjects that are as yet untaught, and would eliminate others which could be safely dropped.

On the assumption that the human brain cannot assimilate the vast number of subjects which may be required for every type of engineering, I venture to state that the production engineer need not have all the qualifications necessary to function as a works engineer—it is not necessary for him to be able to run a power station or carry out maintenance work—he need not be a professor of statics and dynamics, nor deeply versed in the theories of light and heat. Higher branches of science and mathematics, including the calculus, are not necessary equipment for his future efficiency, nor is the power of working out abstruse calculations or stress and strain diagrams of any great value to him in his job.

He has, on the other hand, however, to be taught mechanical drawing and the science of machine tool design, including the theory and practice of jig and tool design. Time study in all its branches, with an appreciation of the value of its application, must be made part of his mental consciousness, and the necessity of a straight line path of progress from manufacturing to assembly ingrained in him. The theory and practice of inter-factory and inter-machine conveying and transport should be such a part of his mental equipment that he senses the process of manufacture —or rather production—in general as well as in detail.

The theory of the economical layout of plant should be included in his curriculum, and the relation of capital to revenue one of his early studies. He should also be taught the theory of organisation. Works organisation is becoming more and more a scientific study with a technique of its own, and should be included in some part of his training.

Whilst no collegiate training can replace the knowledge which only actual experience can give, yet it might be so arranged as to save some of that valuable time which now is lost at the commencement of an engineer's career, during which he is unable for some considerable period to appreciate the why and wherefore of actual productive factory organisation and practice.

What actual subjects should be taught to give the desired result is beyond the scope of my remarks, and indeed would require much thought and consideration before any constructive programme could be made, but these subjects should be carefully chosen to bring about the desired educative effect.

It might perhaps interest you to read through the syllabus of the lecture courses for Mechanical Engineering followed by, say, the Birmingham University, where, generally speaking, the Engineering Course is, in my opinion, second to none in this country. On reading carefully through the subjects it is astonishing to find how few of them are of use in the daily routine of a production engineer. It will be said that it is necessary to give every budding engineer a thorough grounding in all the sciences that govern the processes of design, manufacture, and use of mechanical things before he can specialise in any particular branch, but I venture to suggest that as certain subjects are eliminated and others introduced in, for instance, the fourth year's course for electrical engineers, the same discrimination could be made in the case of production engineers.

In America, which I visited in the Spring, the status of the production engineer is more fully recognised than in our own country, at least in the automobile plants which I had the pleasure of visiting, and I found that the production engineer in America is even more important than the designer, and exercises that necessary control which I am afraid is often lacking in this country.

The designer, whilst an honoured member of the executive, is kept in check by the production engineer and has become trained —I nearly said tamed—to see his inventions through production spectacles. Consequently, although in theory a piece of mechanism may lose a touch of genius in the States, the final design can be readily manufactured and, what is more to the point, sold at a commercial advantage.

In laying out a factory and arranging the operations, the method of mechanically conveying the various details from operation to operation through the factory is treated as an integral part of the layout and is as important as the actual and individual methods of manufacture. We on this side are prone to think of the actual machine operations first and the disposal of its products afterwards, whilst over there the two thoughts are simultaneous.

In America a machine must be kept operating all its time; the period of "cutting wind" whilst the job is being set up being almost entirely eliminated, or reduced to infinitesimal proportions. Loading positions are a feature in practically every jig, and in order to keep a machine doing useful work all the time, two or three operators, or, as they are termed, machine-tenders, are frequently employed.

The assembly lines are, of course, very complete and are practically all mechanically operated. It is here that the work of the production engineer and production manager is tried out. Whatever else happens, the assembly track must never stop unless it is stopped entirely for specific periods, when the men are sent home.

As programmes are variable in the States, especially in the motor car trade, it will be readily understood, when the extraordinarily high outputs are realised, that no stocks of finished cars can be carried. A firm turning out a thousand cars a day could not possibly stock even a day's output, therefore machinery of a drastic nature is employed to cut down supplies from the commencement so soon as the sales programme is reduced. Suppliers of raw and semi-finished material receive telegrams from the buyers to stop supplies, whenever a manufacturer deems it necessary.

What is termed a Works Quota is issued by the production engineer to the various superintendents of the different departments, which shows the exact number of operators that are required for the desired output. Surplus men are instantly suspended and no more men can be paid than are shown on the Works Quota, a copy of which is forwarded to the wages office. A foreman or chargehand who exceeds this number must give an explanation to his superior before the men can be paid.

In speaking firstly of the general rather than any particular aspect of automobile manufacture, it must be remembered that owing to the fortunate position of manufacturers of motor cars in the States, where a very large home market is assured for their production, the capital necessary for large expenditure in plant and equipment can be readily obtained. The period of capital recovery in installing more economical methods is immeasurably shortened, and this is reflected in the much better and more economical equipment of automobile plants in America over those in England. At the same time, however, there are improvements in practice which are well worth investigation with a view to their adoption in this country, as paying propositions, even on much smaller outputs.

Taking the departments in more detail, we find their foundries, especially those concerned with monobloc castings, in a high state of development. Moulding machines are placed conveniently near apron type conveyors, and the operations of fitting in cores,

casting, knocking out, and fettling proceed mechanically in well-ordered sequence. Sand is conveyed from the mixer to hoppers over the moulding machines, and used sand, after the knocking-out process, is taken, by belt conveyors, to the mixer, in a most economical fashion.

In the drop forging plants the type of drop hammer that we generally see in this country is practically non-existent. Over there the " Board " hammer replaces the Brett hammer in this country, whilst the steam hammer is much more in evidence than with us. I notice that your Institution had, some time ago, a very valuable paper from Mr. Brett on the subject of drop forging generally, in which the " Board " hammer is described, but it is a revelation to notice the extraordinary rate of production obtained from these hammers in the States, a production far in excess of the " Board " hammers that are used in this country. This may be due, in part, to the larger quantities, and the fact that the tools need not be changed until either worn out or broken. Furthermore, these " Board " hammers, being self-contained units, are not encumbered with the gantries and supports that are part of the standard design of our own drop hammers. Furnaces and auxiliary plant, such as clipping presses, are all self-contained and can be lifted by crane to any convenient position. Whilst I hold no special brief for the " Board " hammer against the type that we use, there is no doubt in my mind that for quantity production the " Board " hammer has received too little attention in this country.

The press shops in America must be seen to be believed, but here again the large quantities required per day make the multiplication of presses a paying proposition. In the first large press shop that I visited I saw no less than sixty of the largest double-acting toggle presses, weighing some 80 tons each, with separate motor drives, each set up to do one permanent job, the article being passed from press to press until completed. In many of the operations in these large presses the clutch was not required, the working being so timed that it synchronised with the stroke of the press, thus very greatly increasing the speed of operation. They prefer to use a number of dies—sometimes three to four—on a large press, which can be operated by one man, than single dies on a number of small presses.

The " Marquette " pneumatic cushion was also in general use. This attachment is an appliance whereby the bottom die is, as it were, pneumatically supported. On double acting presses it is difficult, owing to the variations found in the gauge of the metal sheets, to set the blank holders so that they will not grip unevenly, causing the metal either to tear or wrinkle when being drawn. With a " Marquette " attachment this variation is taken up and can be arranged so that even pressure, to the full extent of the

draw on all parts of the blank, can be obtained. The air pressure can also be used for ejecting the pressing, and it is also very helpful in setting dies, etc

The smaller pressings are placed, when finished, in corrugated metal containers, with suitable legs, so that electric trucks can raise them off the floor and carry them to their first machining or assembly operation, and this practice was adopted in many factories for stocking and carrying rough materials from the stores to the first operations. This prevented work being stored on the floors and made a much tidier-looking shop than is generally seen in this country.

Very expensive die-making machines were seen in every press shop. These machines, although they cost from four to five thousand pounds each, are a boon to die sinkers, as from a white metal or plaster cast an electric roller, by a pantograph device, actuates a cutter and reproduces the correct shape on the die.

With regard to the machine tool departments, one cannot help but be impressed by the stability and general sturdy construction of the machines used in America, for not only major but for minor operations, and the manner in which the American machine tool manufacturers have grasped and acted upon the special requirements of the automobile industry. One is bound to say that the requirements of American automobile manufacturers are more readily fulfilled in the States than are ours on this side.

It is distressing to find that no English machines can be found in American automobile plants, whereas American machines hold a dominating position in ours. This is not merely a question of tariff walls, as American manufacturers do not consider only the question of price in dealing with economical production. British-made goods in America suffer under no prejudice from any patriotic point of view. If we in this country, therefore, produced machines which carried through any particular operation more economically, or to finer limits than those which Americans can obtain in their own country, a ready sale would be found for them.

When I arrived in Detroit—without any flourish of trumpets, I may remark—I found letters and telegrams from many machine tool manufacturers waiting for me. Representatives of all the well-known firms were, so to speak, on my doorstep to offer interested advice. Who in this country waits on an American automobile manufacturer, when he arrives, to sell him British-made tools? Machines are arriving in ever-increasing quantities from across not only the Atlantic but the North Sea as well, and in spite of all the difficulties under which the British machine tool manufacturer may suffer this should not be the case.

The firm to which I have the honour to belong has been for the last few months busily engaged in ordering extra plant to cope

with their increasing output. Out of a very large expenditure in machine tools, where every sympathetic endeavour is made to give British manufacturers every opportunity of obtaining these orders, over 50 per cent. will probably have to be placed abroad; some of the types of machines required are not even manufactured in this country, and in others the guaranteed production is superior to the offers we have had from makers in this country. It is, of course, true that American machine tool makers start with very great advantages owing to the much more highly developed market in the States for their products, and much greater encouragement from manufacturers.

The high standard of living, and the consequently high rate of pay that has to be given to operatives has provided a stimulus to invent machines capable of reducing hand labour to its lowest limits, and also to increase, so far as possible, the capacity of the machines to produce up to 100 per cent. efficiency in terms of actual running time. The machine tool maker in America not only produces the machine tool itself, but also provides it with the necessary jigs and fixtures to take care of the operations from start to finish.

It is true that British machine tool manufacturers are starting to make up some of the leeway, but they do not at present specialise sufficiently to give all that particular service which automobile manufacturers require. Certain classes of tools are totally neglected in this country, whilst others are not sufficiently advanced to satisfy requirements. Where, for instance, can we obtain, in this country, high production crank turning lathes or crank pin grinders? Who makes a speciality of multiple borers and honing machines? To which firm in this country can we apply for manufacturing internal grinders, automatic milling machines, and the drum type of milling machines? What British firm has produced a satisfactory hydraulically actuated centre grinder? And, what is more important than all, where can satisfactory and accurate machines be obtained, in this country, for cutting spur, bevel, and spiral gears in large quantities?

Germany has made good copies of practically all the best American machine tools, but similar machines cannot be obtained from British manufacturers. Whilst I admit it often goes against the grain to copy, yet I feel sure that firms in this country could, if they would, not only copy but improve upon American tools and obtain many of the orders which now go abroad.

I must admit that there are some brilliant exceptions; there are some firms who are successfully helping to retain this trade for our own country. They give service, and by that term I mean the help, assistance, and the readiness not only to meet requirements, but to suggest new methods and layouts for work that has been, until quite recently, somewhat lacking. On the other hand,

every possible chance to compete ought to be given to them. Any knowledge obtained by the use of foreign tools should be freely placed at their disposal, and it is up to the British manufacturer requiring machine tools, to back up every genuine endeavour to compete, even to the extent of taking risks of a problematical inferiority of performance, if necessary.

It is from the Institution of Production Engineers that constructive criticism and help should come to the advantage of the British machine tool trade. It is from your ranks that the machine tool manufacturers ought, in my opinion, to recruit designers and technical salesmen, practical men from highly productive factories, men who have been used to handling highly developed productive machines, who could by their accumulated knowledge help to improve and adapt the design of tools already existing, either abroad or in this country, and to create new types of machines to improve on present methods.

(*A report of the discussion on this address will be given in the next issue of the Proceedings.*)

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